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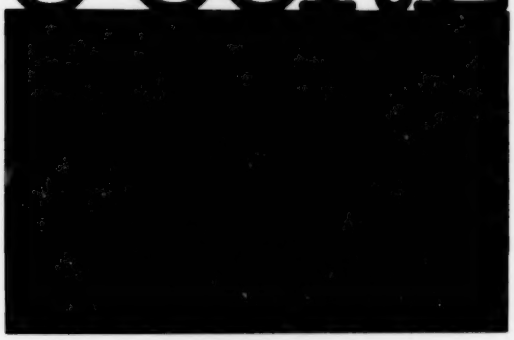

Iceberg Population Distribution Study in the Labrador Sea

K. Andrew Gustajtis

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ABSTRACT

The annual flux of between 500 and 2500 icebergs along the Labrador coast, have given this extremely promising hydrocarbon region the dubious distinction of being called 'iceberg alley'. These mammoth fragments of glacial ice, primarily of Greenland origin, drift southwards under the influences of ocean currents and winds. This report describes the methodology used to produce distribution maps of icebergs in the Labrador offshore from historical iceberg positional data for the years 1963 to 1976 inclusive. A first generation attempt is made to analyze the distribution and predict the probability of an iceberg collision with an offshore structure in this region.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

	Page
ABSTRACT	i
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	v
LIST OF FIGURES	vii
LIST OF TABLES	ix
I INTRODUCTION	1
II ICEBERG ORIGIN AND MOVEMENT	3
III ICEBERG DISTRIBUTION	6
IV ICEBERG IMPACT PROBABILITIES	31
V CONCLUSIONS AND RECOMMENDATIONS	38
REFERENCES	39
APPENDIX I - Digital Data Tape	41

LIST OF FIGURES

		Page
Figure 1	Surface currents in the Davis Strait and Labrador Sea	5
Figure 2	Monthly distribution of the International Ice Patrol's Northern Iceberg Survey Flights (1963-1977)	7
Figures 3 to 14	Iceberg summary per northern survey flight, along the Labrador coast	11
Figure 15	Number of icebergs sighted by the International Ice Patrol per degree square (1963-1967) (modified from Murray, 1969)	34
Figure 16	The flux number of icebergs per degree square and the number of iceberg impacts that 150 meter wide drilling platform would sustain over the entire year	36
Figure 17	The flux number of icebergs per degree square and the number of iceberg impacts that 150 meter wide drilling platform would sustain over individual seasons	37
In Pocket:	Seasonal iceberg density distribution maps of the Labrador coast	

LIST OF TABLES

		Page
Table 1	Size classification of icebergs used by the International Ice Patrol	2
Table 2	International Ice Patrol northern iceberg survey flights (1963-1976)	8
Table 3	Number of icebergs reported per survey flight, as a function of a degree of latitude between 52° and 60°N	10
Table 4	Size distribution of icebergs reported by the International Ice Patrol (1963-1976) per degree latitude	24
Table 5	International Ice Patrol northern survey flights used in the seasonal iceberg density studies	26
Table 6	Absolute number of icebergs per 0.25 degree latitude-longitude square, used in the "Relative Concentration Scales" in the maps enclosed in the pocket of this report	28
Table 7	The probability, P(A), of a collision as a function of latitude between an 100 m wide iceberg and a 150 m wide drilling rig, located in an area one degree of latitude by one degree longitude	32
Table 8	Monthly average flux of icebergs across each degree of latitude (from Anderson, 1971)	33

I INTRODUCTION

Icebergs have always been a significant hazard to shipping and navigation in the Northwest Atlantic, especially in the late winter and early spring when they are most frequently encountered. Further north, along the coasts of Labrador and Baffin Island, icebergs are present throughout the year, with a seasonal peak in early summer and mid fall respectively. With the advent of offshore exploration on the Canadian east coast and its gradual progression northward, icebergs have been identified as one of the most serious obstacles faced by the oil industry (Duval, 1975).

An overall assessment of the potential risk that icebergs exert on offshore activity is unknown. Only a basic understanding of their movement and the forces governing their motion is known, (Dempster, 1974). Many of the physical problems associated with iceberg distribution, drift and scouring would be greatly simplified if sufficient statistical information could be complied on such variables such as their seasonal regional distribution, their quantities, their size and shape, and other pertinent environmental factors such as currents, tides, wind patterns, and bathymetry which are known to both effect the movement and eventual deterioration of the icebergs.

This report is an attempt to summarize available information on icebergs in the Labrador Sea from approximately latitudes 52°N to 60°N, using the International Ice Patrol size classification (Table 1). Data on icebergs south of 52°N are contained in the annual reports of the International Ice Patrol Service in the Northwest Atlantic.

Table 1 Size classification of icebergs used by the International Ice Patrol

Description	Height (metres)	Length (metres)	Approximate weight (Megatons)
Growler	Under 1.5	Under 5	0.001
Bergy Bit	1.5 - 15	5 - 15	0.01
Small Berg	5 - 15	15 - 60	0.1
Medium Berg	15 - 50	60 - 120	2.0
Large Berg	50 - 100	120 - 220	10.0
Very Large Berg	>100	>220	>10.0

II ICEBERG ORIGIN AND MOVEMENT

There are approximately 100 iceberg-producing glaciers on the west coast of Greenland, of which about twenty are principally responsible for the vast majority of icebergs which eventually drift into the North Atlantic.

As many as 40,000 icebergs can calve from these west Greenland glaciers annually. The largest concentration of bergs is usually found in Melville Bay and westward to Cape Atholl (Murray, 1969). In many cases the calved icebergs ground almost immediately. An example of this process is evident in front of the Humbolt glacier, with a terminus approximately 97 km wide at its outer edge. Individual icebergs may be identified from one year to the next, still grounded off the outer edge of the Humbolt glacier. The combination of the encompassing sea ice and the grounding prevents movement except for perhaps only very brief times such as spring tides (Feazel and Kollmeyer, 1972).

The east Greenland glaciers, where it is estimated that about half as many icebergs are calved as in west Greenland, account for only 10% of the number of icebergs reaching the north Atlantic. The remaining 5% are thought to come from glaciers and ice shelves of northern Ellesmere Island and, to a lesser extent, of Baffin Island.

Water currents appear to be the principal driving force in moving the icebergs from Baffin Bay to Grand Banks (Kollmeyer, 1964; Dempster and Bruneau, 1973). Icebergs with large drafts are influenced more by deep steady currents while small bergs appear more sensitive to wind-induced surface currents. The importance of direct wind force is a function of the above water shape of the berg and the wind velocity.

Winds appear to have negligible effect on iceberg speed unless the velocity of the wind is greater than 25 to 30 knots and blowing from an approximately constant direction for several hours (Dempster, 1974).

The main feature involved in the ocean circulation in the Labrador Sea and Baffin Bay is the northward flow of the West Greenland Current along the continental slope of West Greenland, and a southward movement along the east coast off Baffin Island and Labrador. The West Greenland Current is composed of the East Greenland Current and the Irminger Current which becomes re-energized on rounding Cape Farewell. The Labrador Current is the combination of the flows of the Baffin Island and West Greenland Currents, with added energy from the waters moving outwards from Hudson Bay and Foxe Channel through Hudson Strait (Fig. 1).

SURFACE CURRENTS

August - September

(from Dunbar, 1951)

Figure 1 Surface currents in the Davis Strait and Labrador Sea

III ICEBERG DISTRIBUTION

The most important source of information about icebergs, in the northwest Atlantic, is the International Ice Patrol. Since the tragic sinking of the Titantic in 1912, the formation of the International Ice Patrol under the auspices of the U.S. Coast Guard has had the mandate to track and report those icebergs that drift into the busy shipping lanes south of 48°N latitude off eastern Newfoundland. In these southern waters the iceberg threat exists from approximately early March to late June. With warming waters progressing further north after June most southerly drifting icebergs generally melt before passing as far south as 48°N latitude. In 1963 the International Ice Patrol commenced what was to become known as their northern iceberg survey flights. The main objective of these preseason flights was to forecast the character of the forthcoming Grand Bank iceberg season, and thereby determining the iceberg potential (Lenczyk, 1965). A summary report of these northern survey flights in terms of a number of icebergs sighted per degree square of latitude and longitude have appeared in the appropriate annual Bulletins of the International Ice Patrol Service in the North Atlantic Ocean.

Figure 2 and Table 2 are a summary of the various northern iceberg survey flights carried out since 1963 to the present as well as a breakdown of the monthly coverages undertaken during this time period. Also included in this figure are the geographic areas covered by the individual flight. One of the features that becomes evident in examining these data is the reduction of northern iceberg survey flights to essentially the months of January and February since 1971.

The original flight charts which contained the individual iceberg

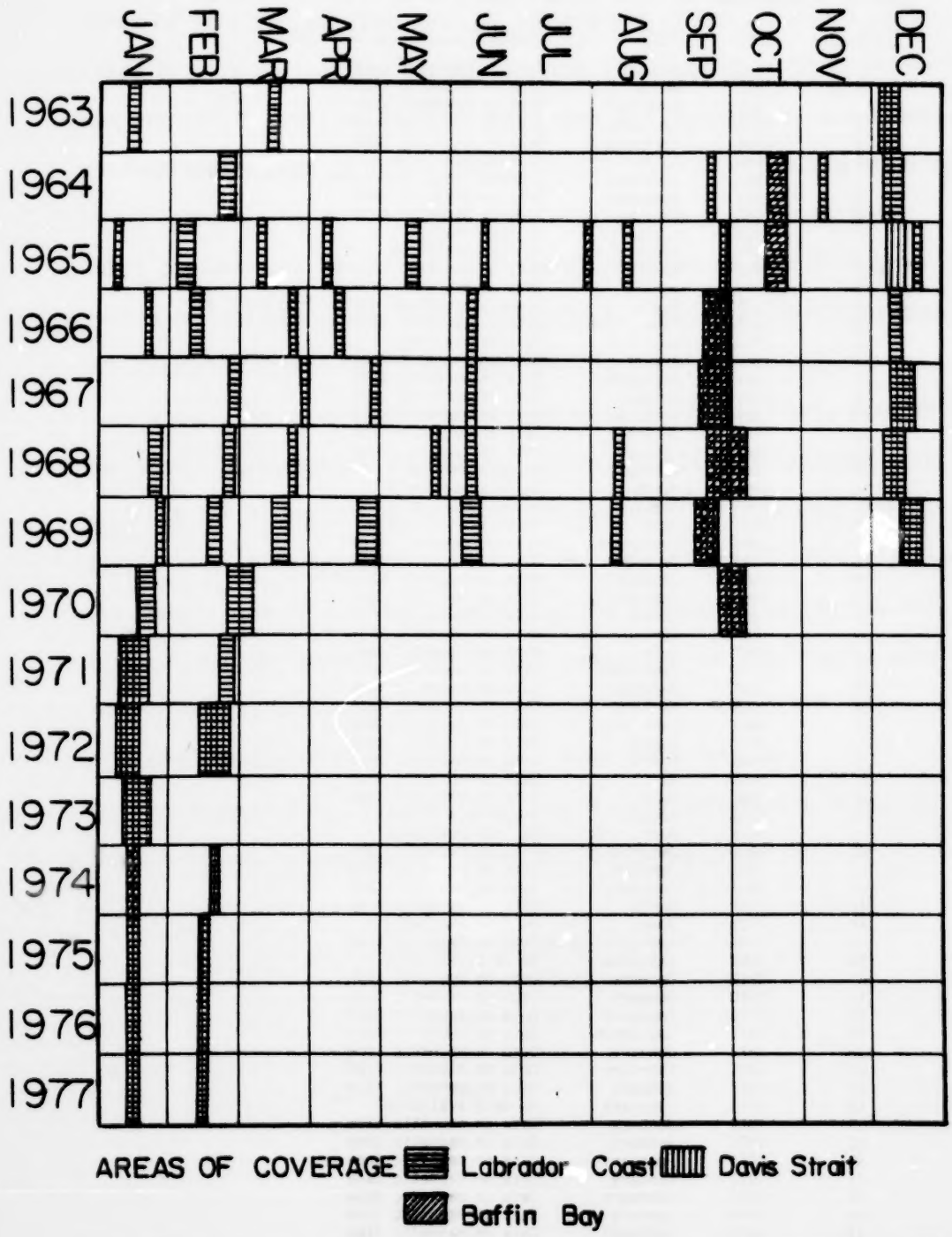


Figure 2 Monthly distribution of the International Ice Patrol's Northern Iceberg Survey Flights (1963-1977)

Table 2 International Ice Patrol northern iceberg survey flights (1963-1976)

Flight Nos.	Year	Month	Status of Flight Information
1	1963	January	Data on magnetic tape
2	1963	March	Data on magnetic tape
3	1963	December	Data on magnetic tape
4	1964	February	Data on magnetic tape
5	1964	September	Data on magnetic tape
6	1964	October	No data available
7	1964	November	Iceberg locations copied from Bull. #50
8	1964	December	Data on magnetic tape
9	1965	January	Data on magnetic tape
10	1965	February	No data available
11	1965	March	No data available
12	1965	April	Data on magnetic tape
13	1965	April	Data on magnetic tape
14	1965	May	Iceberg locations copied from Bull. #50
15	1965	June	Data on magnetic tape
16	1965	July	No data available
17	1965	August	Data on magnetic tape
18	1965	September	Data on magnetic tape
19	1965	October	Data on magnetic tape
20	1965	December	Data on magnetic tape
21	1965	December	Data on magnetic tape
22	1966	January	Data on magnetic tape
23	1966	February	No data available
24	1966	March	No data available
25	1966	April	No data available
26	1966	June	No data available
27	1966	September	Data on magnetic tape
28	1966	December	Data on magnetic tape
29	1967	January	Data on magnetic tape
30	1967	February	Data on magnetic tape
31	1967	March	Data on magnetic tape
32	1967	April	Data on magnetic tape
33	1967	June	Data on magnetic tape
34	1967	September	Data on magnetic tape
35	1967	December	Data on magnetic tape
36	1968	January	Data on magnetic tape
37	1968	February	Data on magnetic tape
38	1968	March	Data on magnetic tape
39	1968	April	Data on magnetic tape
40	1968	May	Data on magnetic tape
41	1968	June	Data on magnetic tape
42	1968	August	Incomplete flight
43	1968	Sept. - Oct.	No data available
44	1968	December	Data on magnetic tape
45	1969	January	Data on magnetic tape
46	1969	February	Data on magnetic tape
47	1969	March	Data on magnetic tape
48	1969	June	No data available
49	1969	August	Data on magnetic tape
50	1969	September	No data available
51	1969	December	Data on magnetic tape
52	1970	January	Data on magnetic tape
53	1970	February	Data on magnetic tape
54	1971	September	Data on magnetic tape
55	1971	January	Data on magnetic tape
56	1971	February	Data on magnetic tape
57	1972	January	Data on magnetic tape
58	1972	February	No data available
59	1973	January	Data on magnetic tape
60	1974	January	Data on magnetic tape
61	1974	February	Data on magnetic tape
62	1975	January	Data on magnetic tape
63	1975	February	Data on magnetic tape
64	1976	January	Data on magnetic tape
65	1976	February	Data on magnetic tape
66	1976	March	Data on magnetic tape

locations are archived with the U.S. Coast Guard. Using these original flight charts, individual iceberg sighting locations were retrieved in terms of latitude and longitude to the nearest minute as well as any shape or size designation associated with the icebergs. This information was eventually compiled on a magnetic tape and accounts for a presently available data bank of approximately 26,000 individual iceberg sightings as recorded by the International Ice Patrol north of 52°N latitude. Table 3 summarizes the number of icebergs reported on each flight per degree of latitude along the Labrador coast. Copies of this data tape are available from C-CORE (see Appendix I).

One of the unfortunate features evident in the available data is the unequal geographical coverages. As an example, the Labrador coast accounts for 97 percent of the northern survey flights whereas the Davis Strait and Baffin Bay regions account for only 43 and 14 percent respectively. The combination of a better coverage of the Labrador coast during this fifteen year period and the increased urgency of the anticipated development in the region, motivated a restriction of initial interest to Labrador offshore stretching from 52°N to just above 60°N latitude.

In figures 3 to 14, inclusive, the iceberg information along the Labrador coast is summarized, using the following symbols:

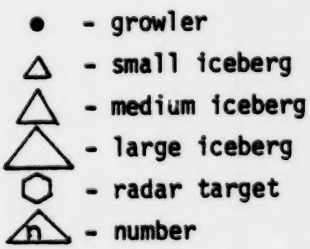
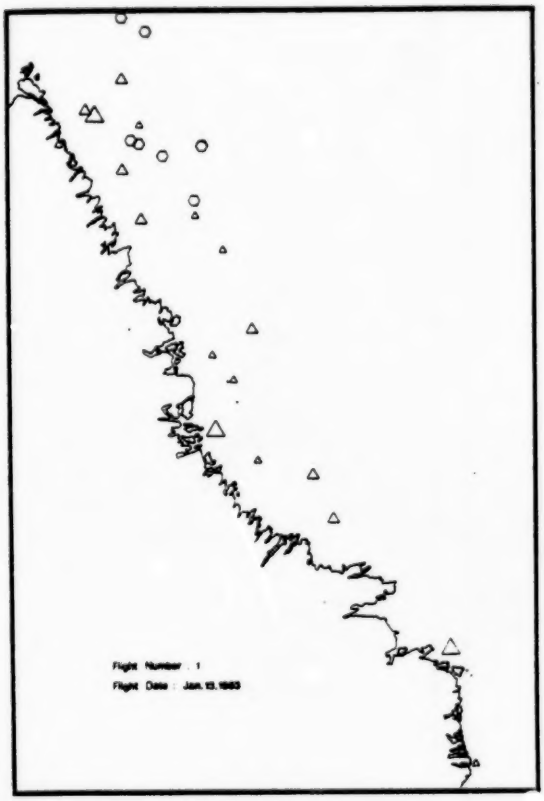
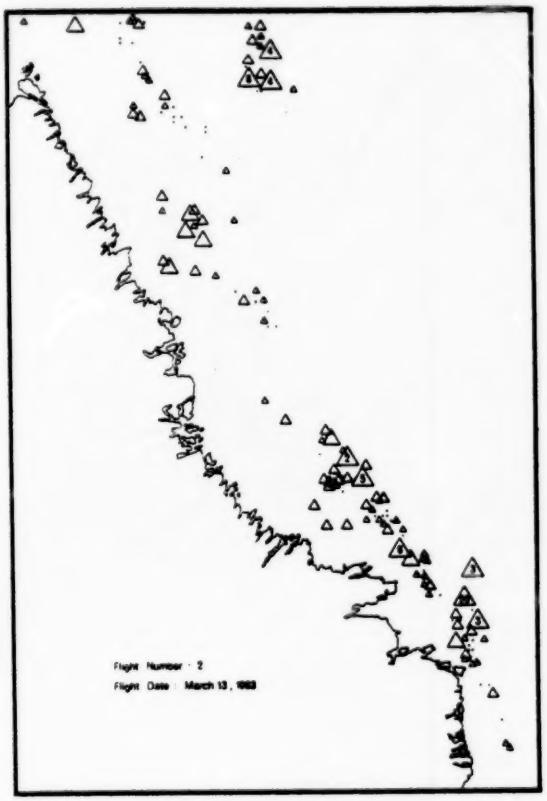


Table 3 Number of icebergs reported per flight, as a function of a degree of latitude between 52°N and 60°N

Flight Number	Latitude								
	52	53	54	55	56	57	58	59	60
1	106	140	314	488	369	39	54	43	25
2	22	44	41	5	10	10	14	17	43
3	0	1	1	6	4	28	21	37	41
4	40	5	81	160	123	111	59	42	54
5	20	23	23	19	15	9	18	12	8
6	NO DATA								
7	1	1	4	3	5	0	3	6	3
8	2	1	0	2	4	4	12	19	11
9	0	0	0	11	22	33	23	30	21
10	NO DATA								
11	NO DATA								
12	0	0	11	31	9	0	7	36	23
13	16	2	28	18	19	16	31	7	0
14	6	9	20	44	32	25	21	22	8
15	NOT CALCULATED								
16	NO DATA								
17	1	5	4	19	10	9	8	14	8
18	0	1	0	1	4	1	5	2	0
19	0	0	0	5	0	0	0	0	0
20	0	0	0	0	0	3	3	20	0
21	0	0	0	0	0	1	2	6	9
22	0	0	1	8	19	10	22	11	2
23	NO DATA								
24	NO DATA								
25	NO DATA								
26	NO DATA								
27	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	1	1	1	0
29	0	0	5	12	45	19	26	8	15
30	27	23	48	71	31	23	3	0	0
31	10	12	57	9	38	11	2	0	1
32	0	0	14	9	22	6	1	0	0
33	9	17	43	18	62	34	43	8	8
34	0	0	0	0	2	1	1	2	1
35	1	0	0	0	0	0	2	0	0
36	0	0	0	0	2	0	7	20	0
37	45	68	15	46	65	46	48	105	50
38	28	29	0	0	0	0	0	0	0
39	29	81	56	101	76	23	23	1	0
40	59	23	40	0	0	0	0	0	0
41	9	0	0	0	0	0	0	0	0
42	IN COMPLETE								
43	NO DATA								
44	1	0	0	0	0	1	3	6	14
45	0	0	0	0	7	3	7	16	5
46	0	0	3	7	10	14	19	21	33
47	2	4	10	36	63	39	32	55	42
48	NO DATA								
49	22	25	27	3	0	0	0	0	0
50	NO DATA								
51	0	0	0	0	1	3	5	5	14
52	1	6	0	2	15	40	39	25	17
53	8	15	21	117	118	169	123	88	71
54	0	0	0	0	0	2	0	0	0
55	1	1	0	6	4	11	3	1	2
56	32	44	32	91	71	46	55	45	28
57	4	2	3	15	15	9	3	1	5
58	NO DATA								
59	32	46	12	0	17	14	8	2	0
60	0	0	0	0	27	14	24	29	29
61	127	36	0	1	100	214	181	111	154
62	2	1	5	8	4	6	4	1	5
63	2	46	49	117	8	22	13	13	12
64	0	3	14	11	3	4	12	20	4
65	6	7	5	4	5	16	8	4	5





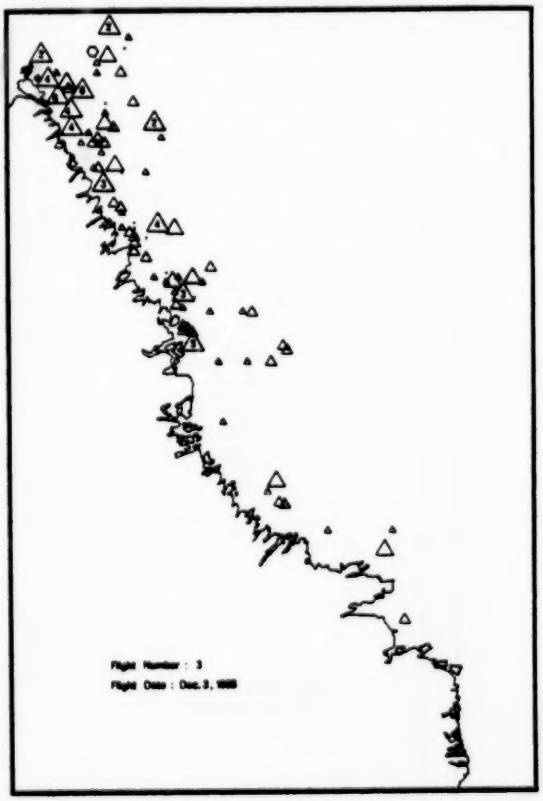
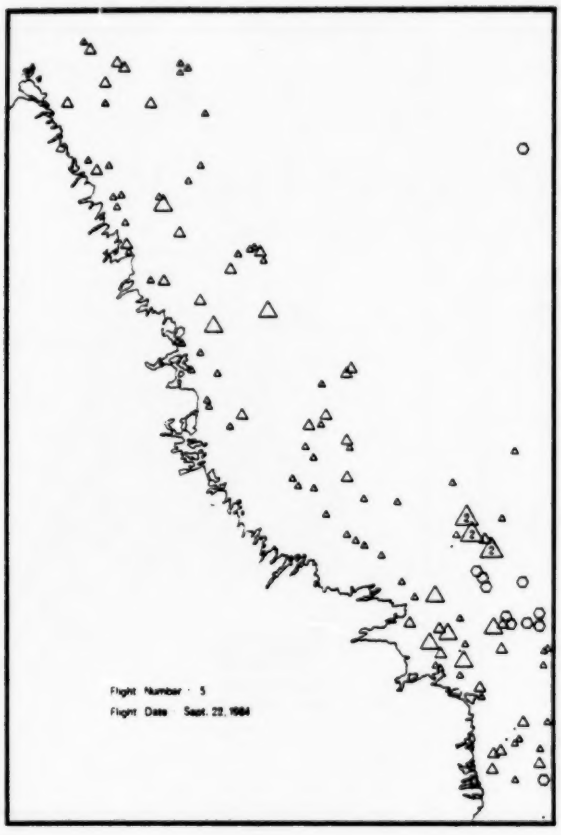


Figure 3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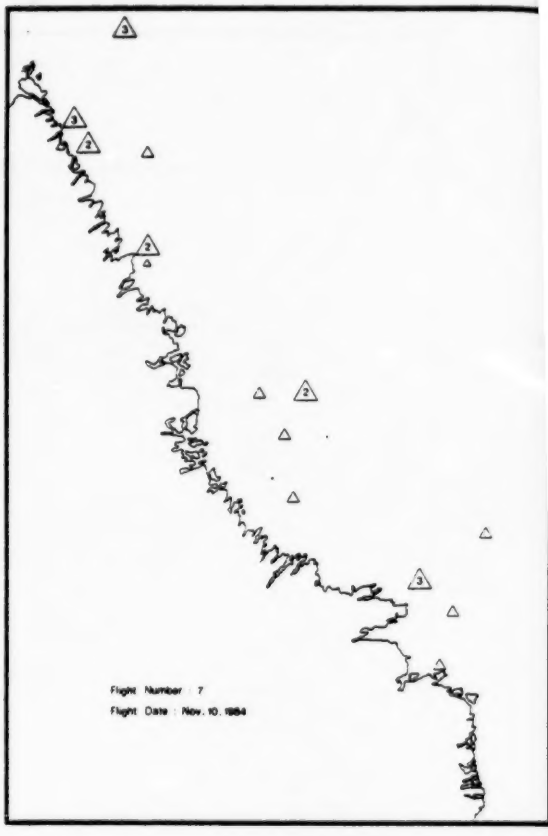
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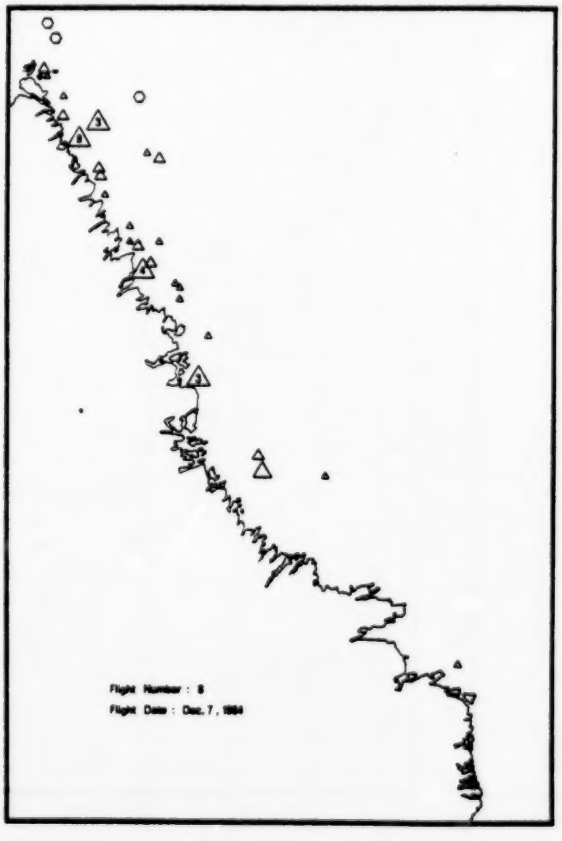
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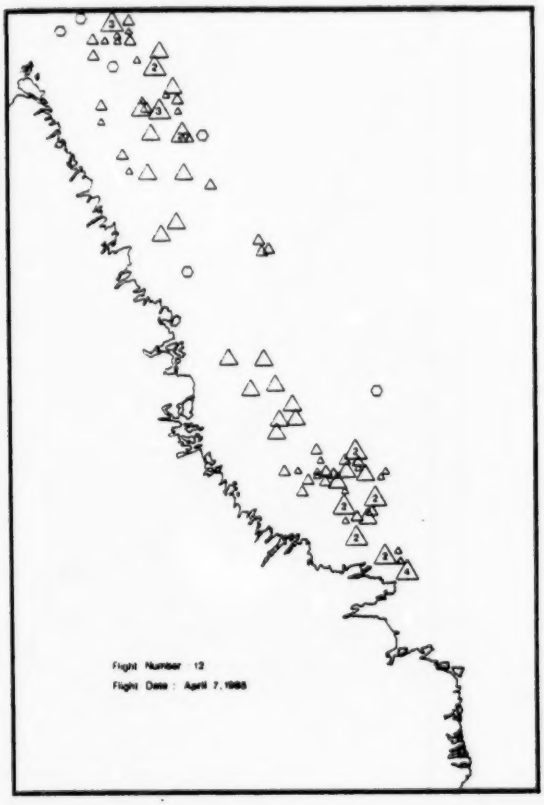
Figure 4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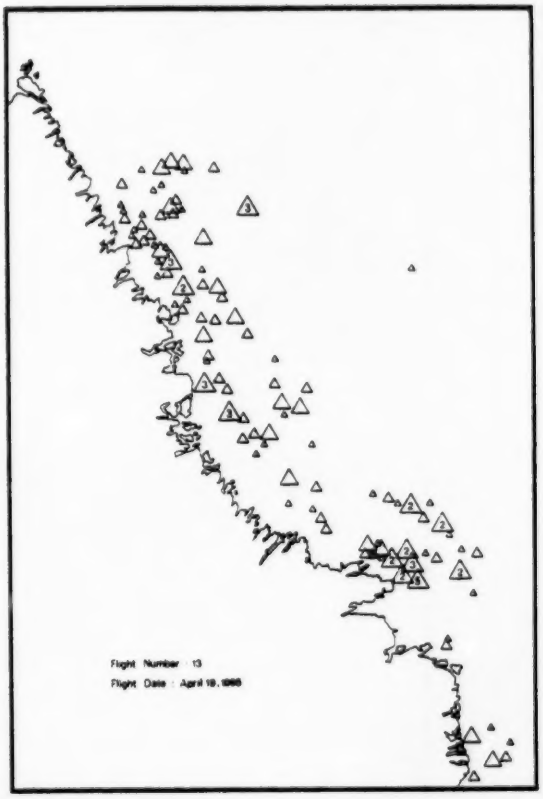
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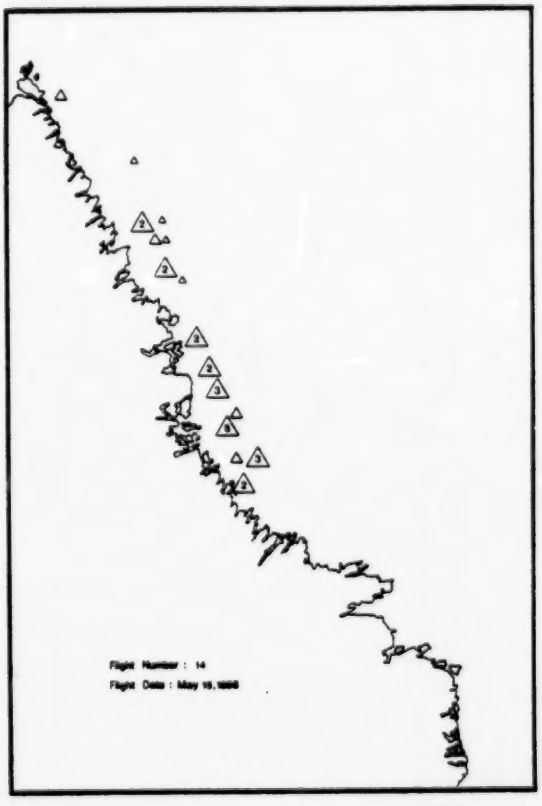
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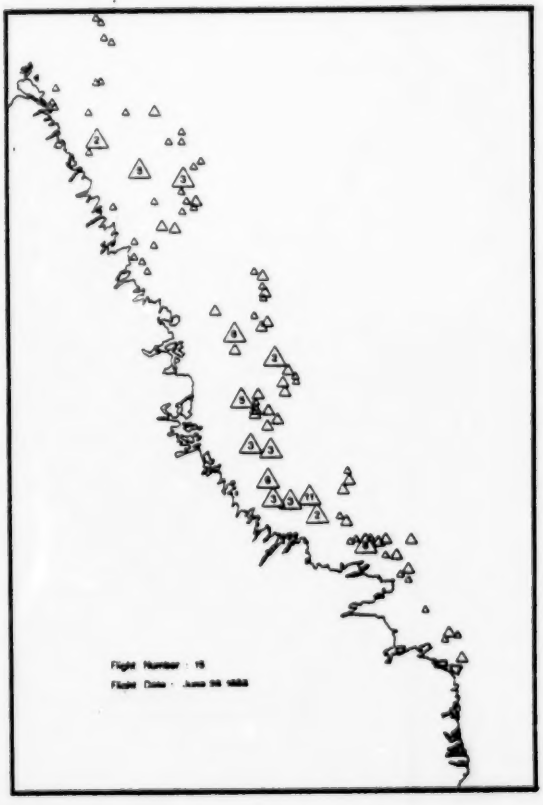
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Figure 5

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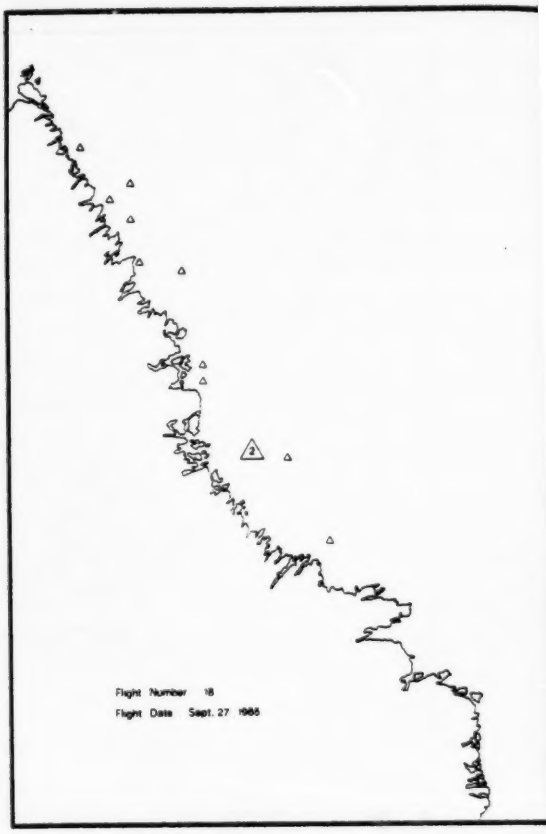
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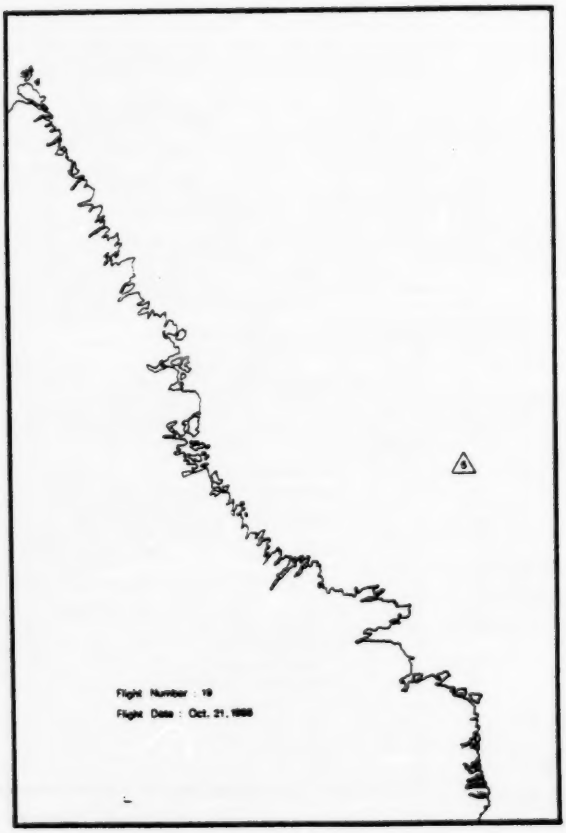
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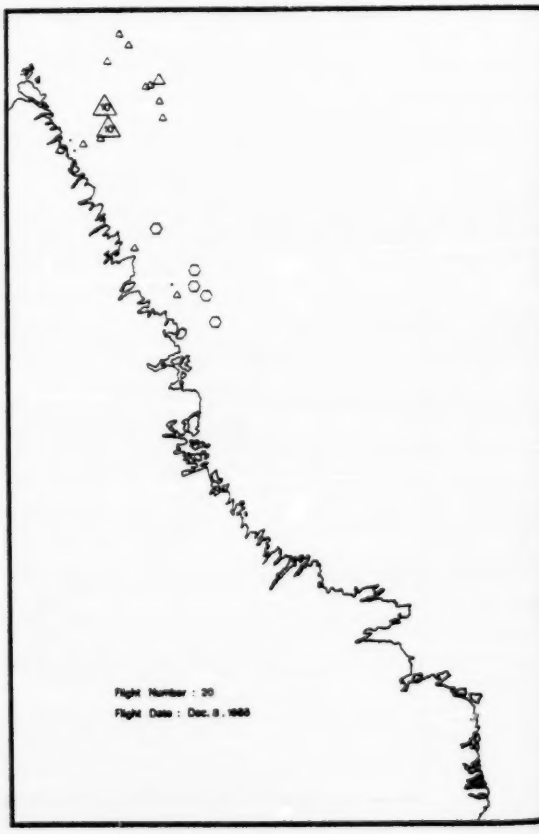
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Figure 6

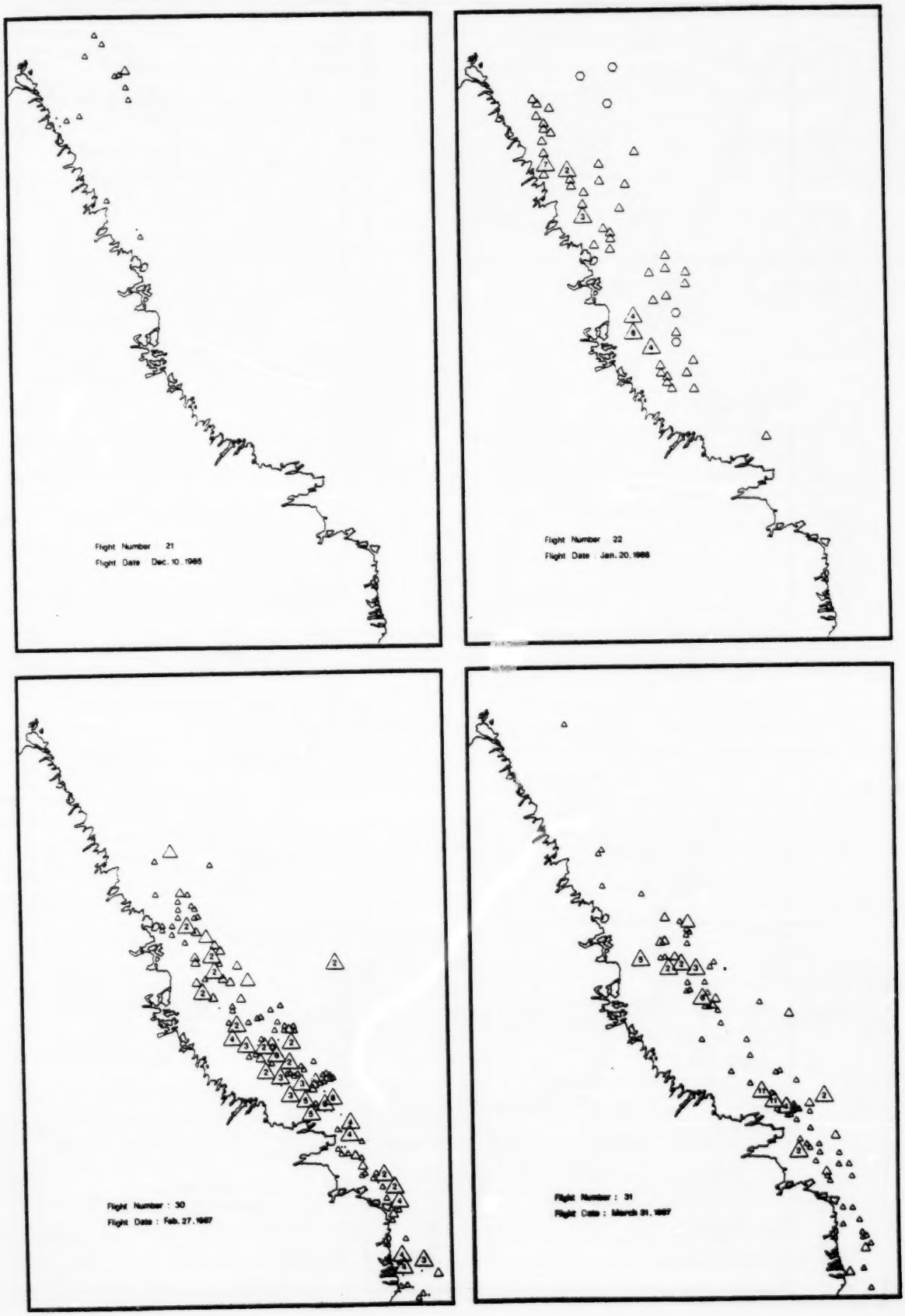
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Figure 7

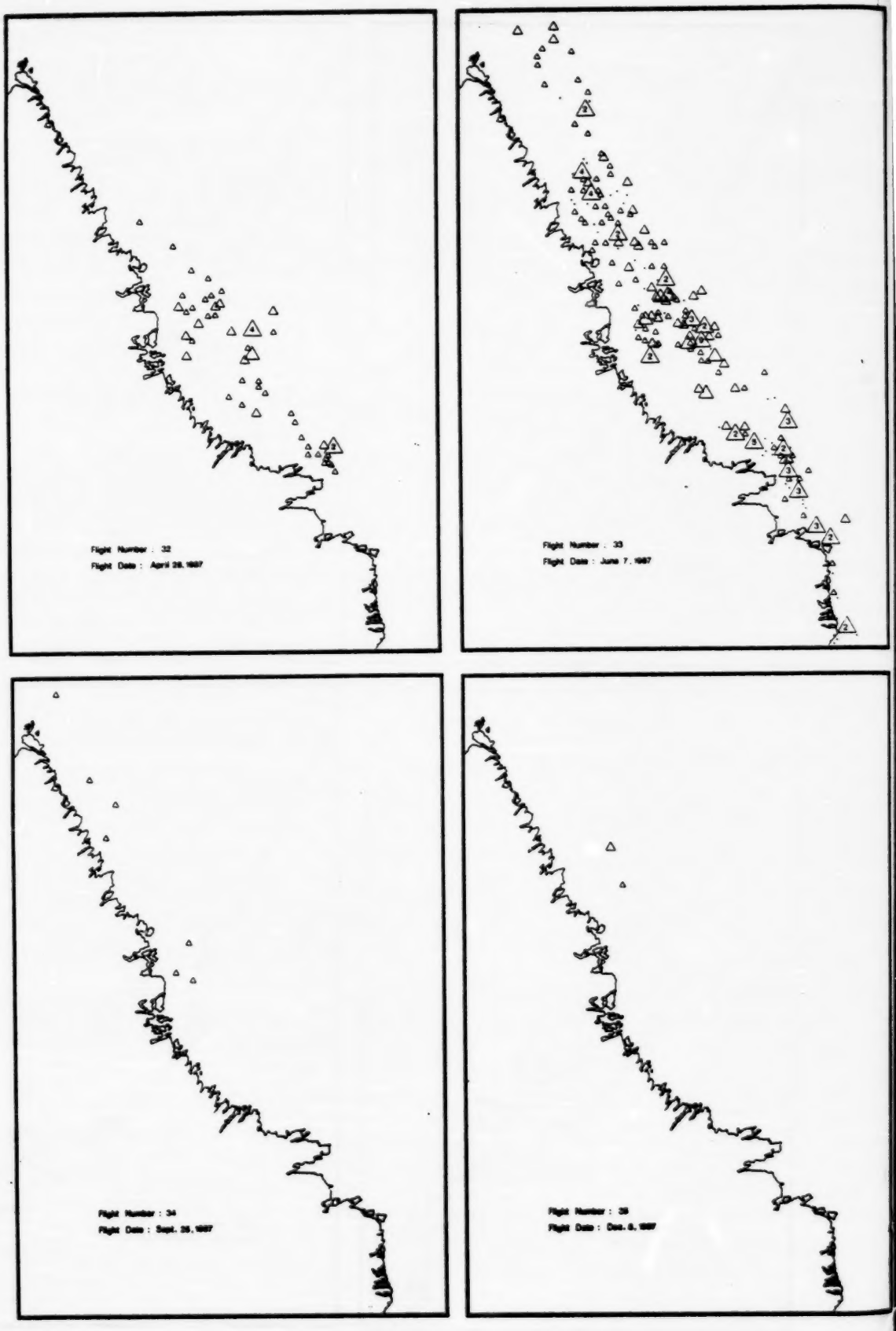
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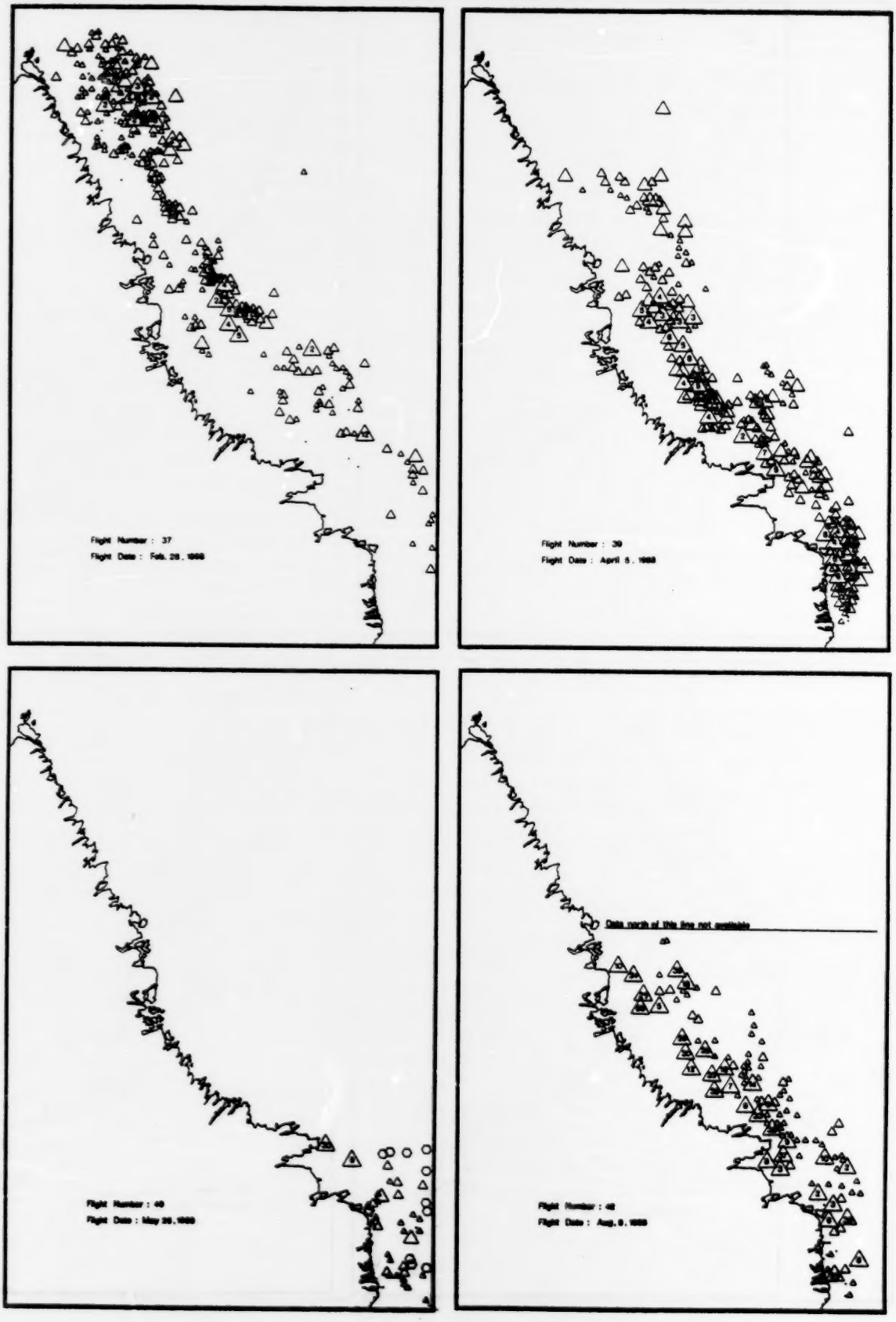
Figure 8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Flight Number : 39
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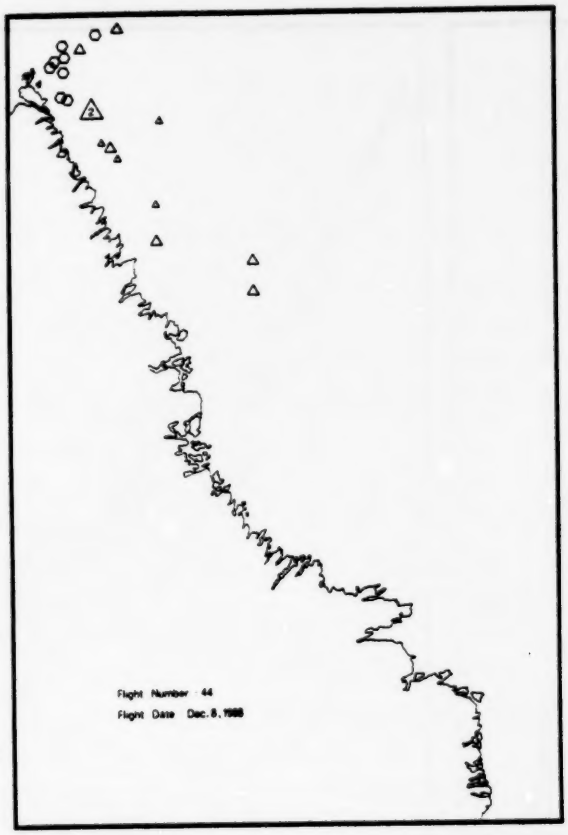
Flight Date : Aug. 8, 1988

Figure 9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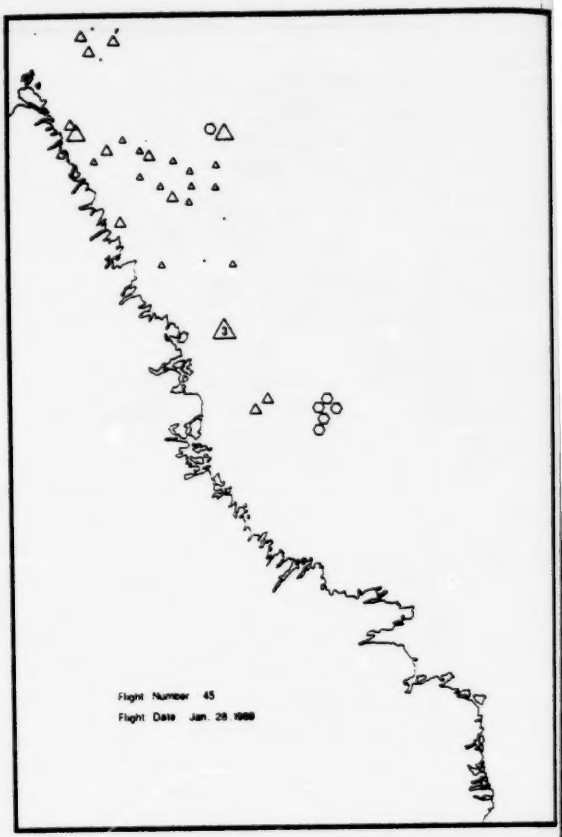
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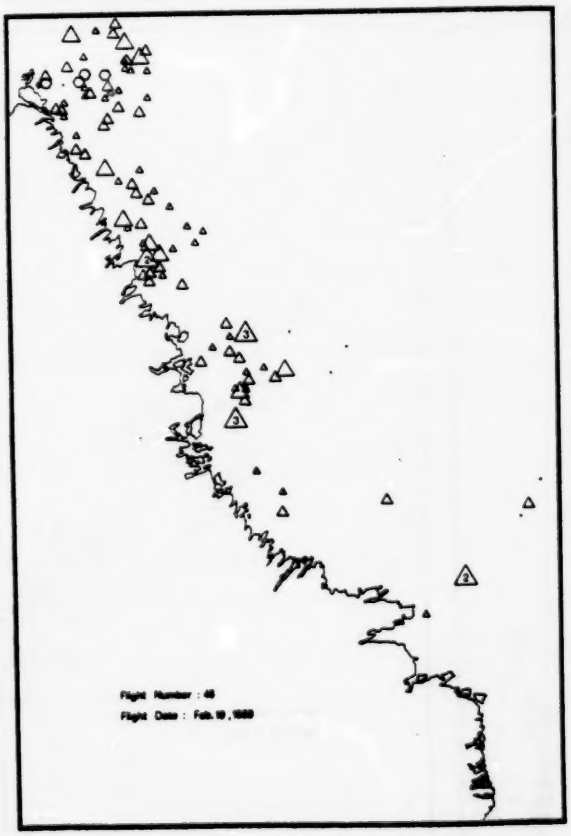

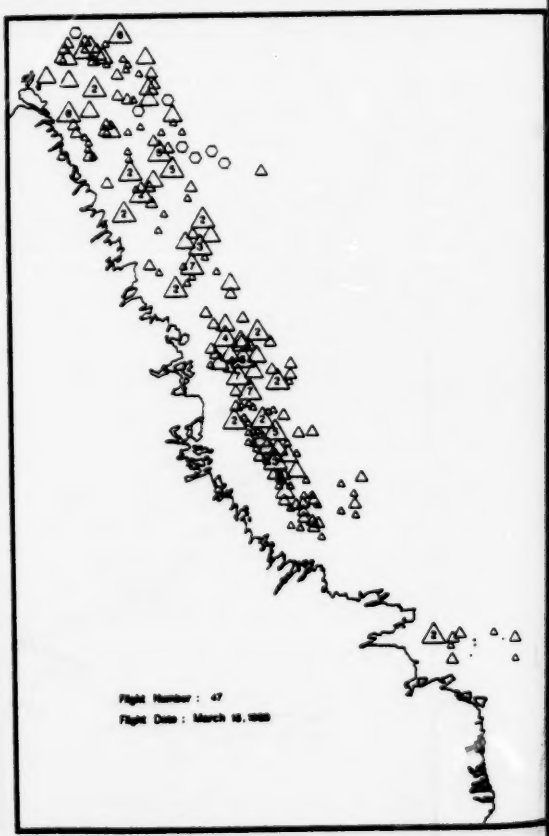

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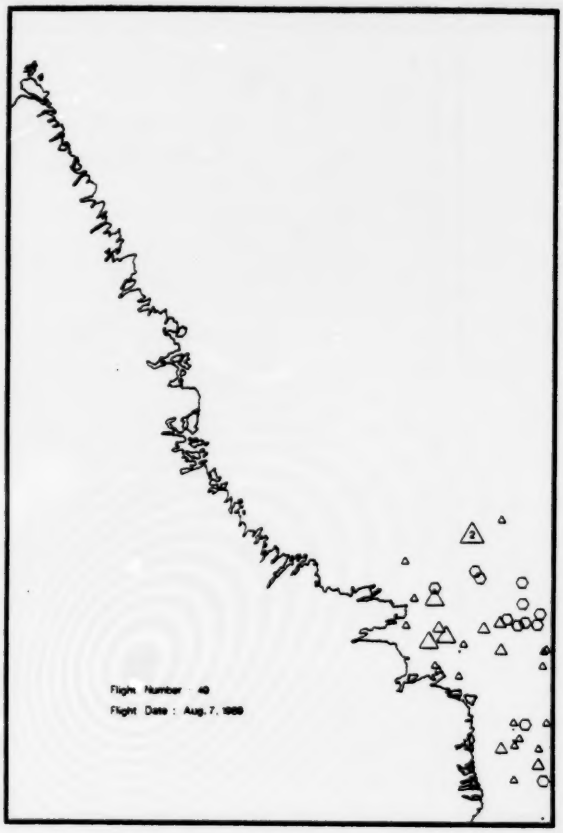
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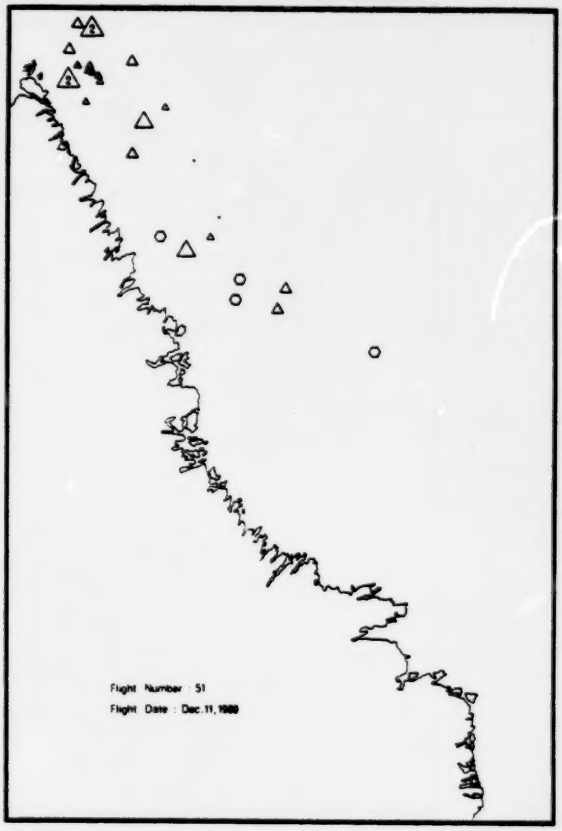
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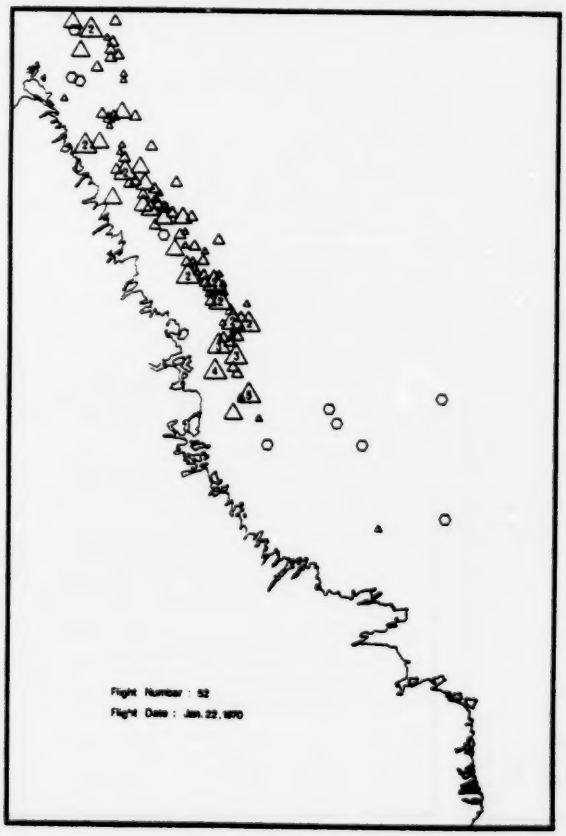
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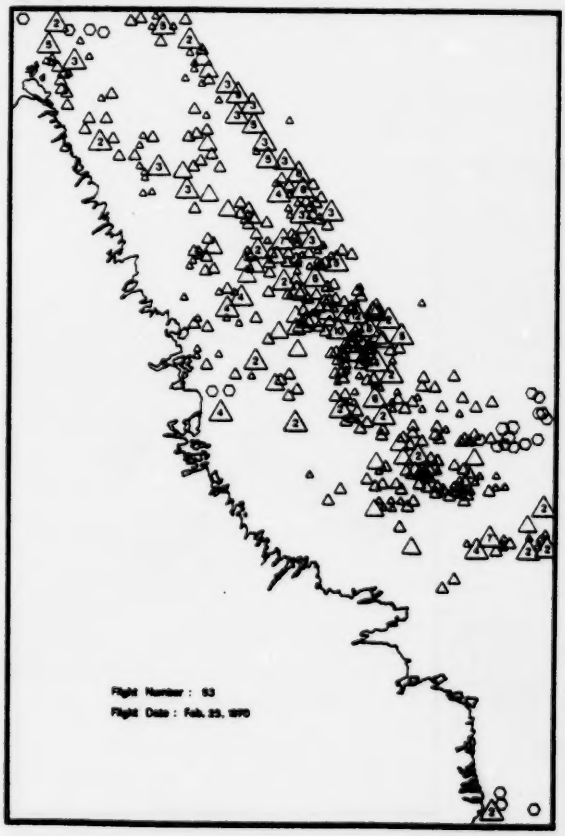
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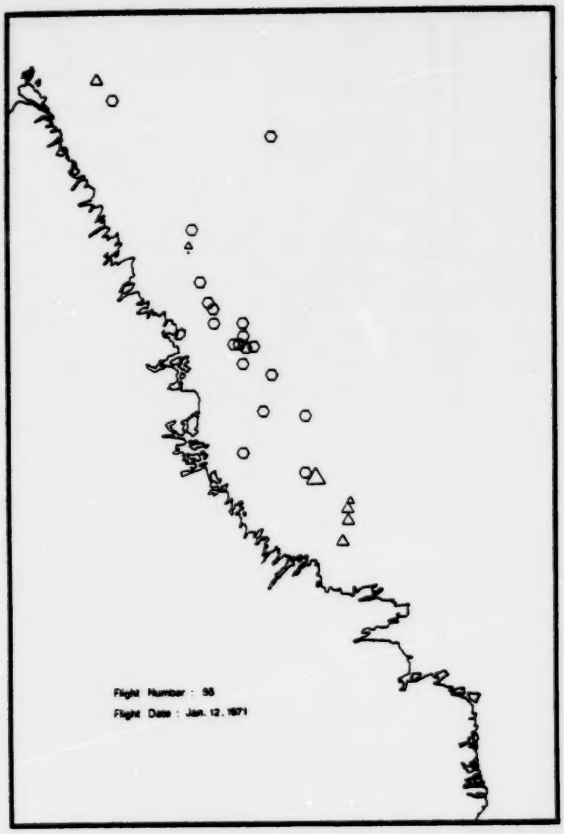
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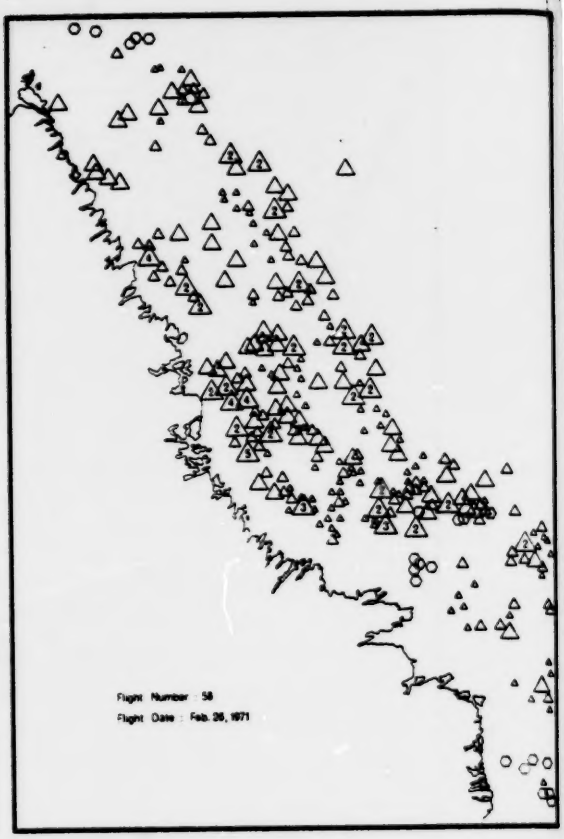
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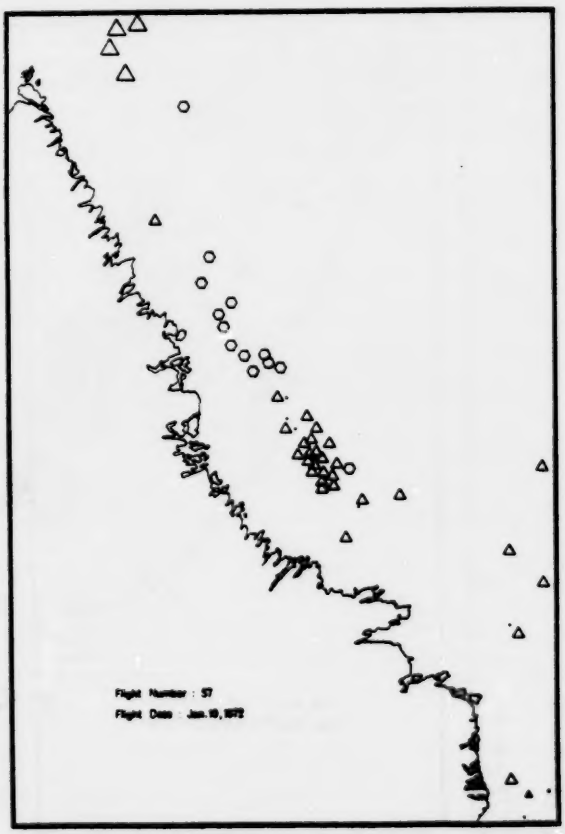
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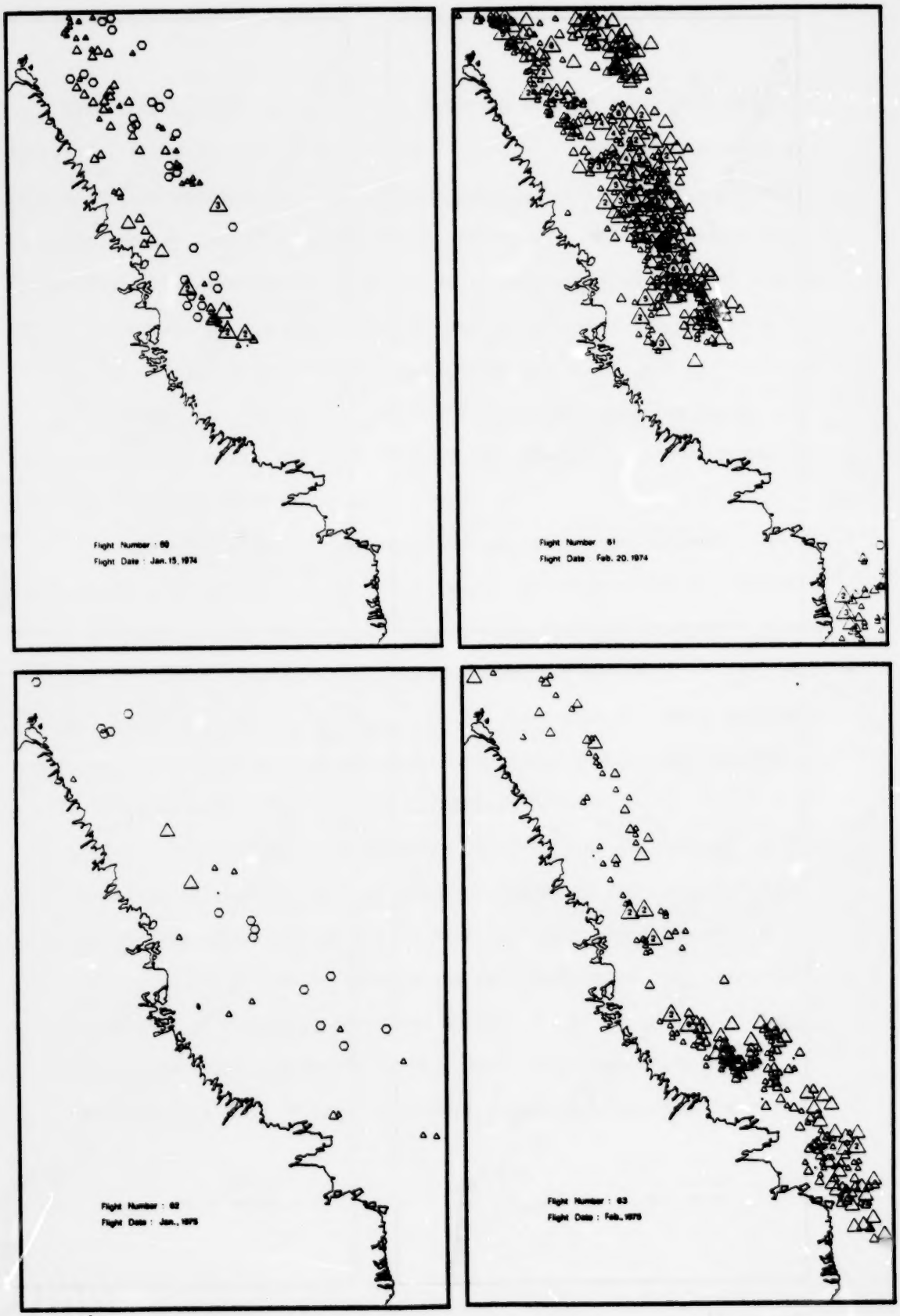
Flight Number : 59

Figure 12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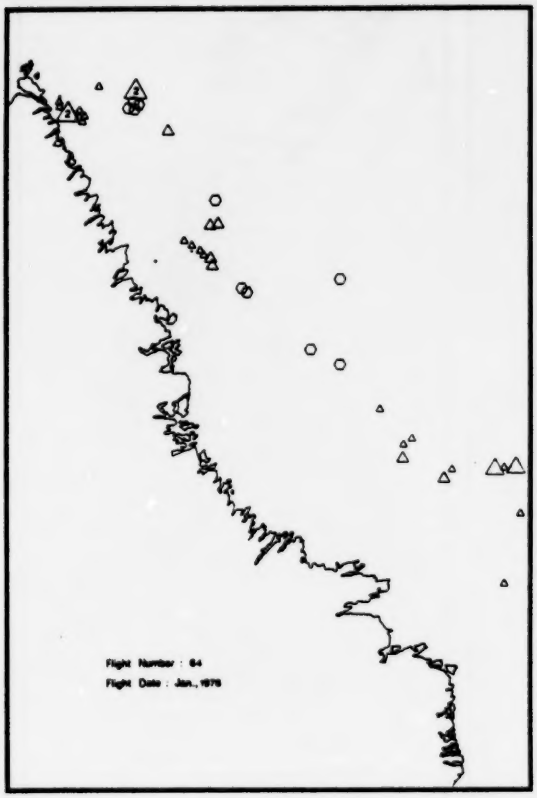
Flight Number : 61
Flight Date : Feb. 20, 1974
Flight Number : 62
Flight Date : Jan., 1975
Flight Number : 63
Flight Date : Feb., 1975

Figure 13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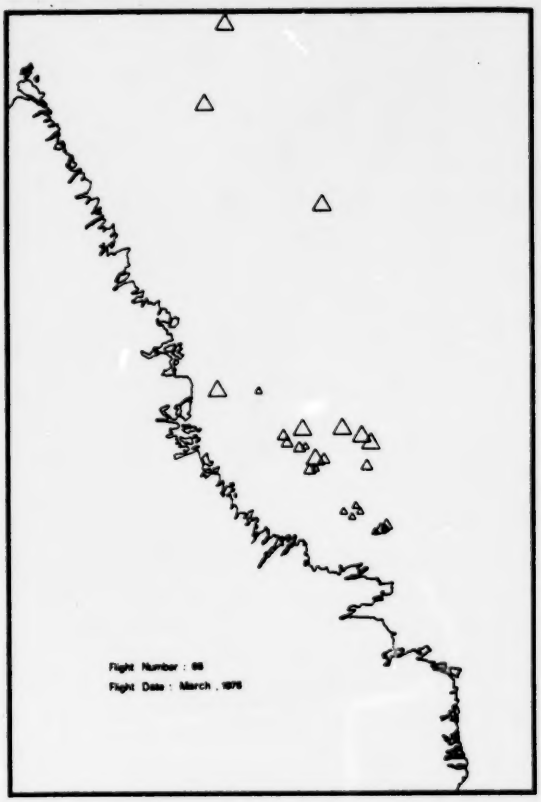
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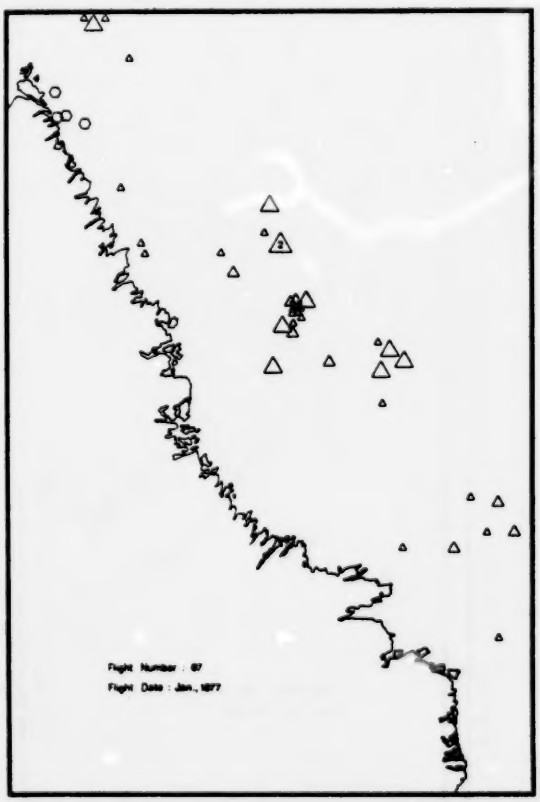
Flight Number : 67
Flight Date : Jan., 1977

Flight Number : 68
Flight Date : March , 1977

Figure 14

Both total number as well as the relative size of individual icebergs decreases southward from 60°N latitude. Table 4 illustrates the iceberg size distribution found for the Labrador region. Large icebergs defined as those greater than 100 meters across, decrease in relative number from approximately 15% in northern Labrador to approximately 6% at 52°N, whereas growlers increase by approximately the same proportion. The data base for this table is derived from flights made during the winter and early spring by the International Ice Patrol (1963-1977 inclusive). In the summer and fall a similar distribution would be expected, however the total proportion of larger icebergs would be reduced.

Using computer mapping routines discussed below, the intention was to generate a series of iceberg density distribution maps for the Labrador offshore. Inadequate monthly coverages throughout the fifteen year period preclude monthly distributions and necessitated the generation of seasonal regional population distribution. To ensure approximately equal seasonal coverages, as well as periods of approximately equal gross environmental similarities, the four seasons were divided as follows:

Winter; with dropping surface water temperatures, and initial formation of sea ice included November, December and January

Spring; represented by extensive pack ice cover along the entire coast, and surface water temperature uniformly below 0°C, comprises the months of February, March and April

Summer; included the months of May, June, July and August and represented a time of warming surface waters and the final retreat of the sea ice

Table 4 Size distribution of icebergs reported by the International Ice Patrol (1963-1976) per degree latitude

	Percent Distribution			
°N	Growlers	Small	Medium	Large
60	6.4	43.3	33.5	16.8
59	4.2	49.9	29.4	15.5
58	4.2	48.0	36.6	11.2
57	4.3	41.9	42.2	11.7
56	5.1	51.6	34.1	9.3
55	3.9	61.4	27.8	7.0
54	16.6	52.3	24.5	6.7
53	10.2	52.4	26.5	10.9
52	16.7	52.2	24.6	6.5

Fall; represented predominatly by September and to a lesser extent by October was a period of the warmest surface waters.

To avoid either over-biasing or under-biasing certain regions as a result of flights which either terminated prior to a complete coverage of the coast, or because of poor visibility surveyed only part of the Labrador Shelf, they were by necessity eliminated from further consideration in the generation of the iceberg density distributions. Table 5 lists the flights that were used in the generation of the distribution maps.

The smallest practical sample size in studying the iceberg density distribution was found to be 0.25 square degree of latitude and longitude which represents an area approximately 225 square nautical miles. Iceberg numbers were insufficient to allow a smaller sample size.

The generation of the actual density maps contained in the pocket of this report were carried out using the contouring options of SYMAP - a computer mapping program using a standard line printer as its output. The program was specifically designed to be used in the analysis of spatial data (Dougenik and Sheehan, 1975). The entire Labrador Coast was divided into 0.25 degrees of latitude and longitude, and the number of icebergs in each area was determined. These iceberg densities were assigned to the centroids for each of the unit areas along the entire coast. The SYMAP program interpolated contour lines representing locations of equal iceberg population densities.

The basic assumption made in this study was that the distribution was not a random process but controlled by environmental factors. Therefore, a density distribution pattern of iceberg populations would be expected to emerge providing sufficient iceberg numbers were available.

Table 5 International Ice Patrol northern survey flights used in the seasonal iceberg density studies

Season	Flight No. (see Table 6)
Winter	1, 3, 7, 8, 9, 20, 22, 29, 45, 51, 52, 55, 57, 59, 60, 62, 64
Spring	2, 4, 12, 37, 46, 47, 53, 56, 61, 63, 65
Summer	14, 15, 17, 33, 40, 41, 42
Fall	5, 7, 18, 27, 34

Note

(1) Flights 13, 19, 21, 28, 30, 31, 32, 35, 36, 38, 39, 44, 49, 57 and 66 were not used because of insufficient coverages.

(2) Flights 67 and 69 were not available.

(3) No data available for flights 6, 10, 11, 16, 23, 24, 25, 26, 42, 43, 48, 50 and 68.

As the available data were insufficient to provide for average monthly patterns, due to scarcity of data, relative densities were only possible for seasonal distributions. To ensure comparison possibilities between seasons, similar intensity levels were chosen. Table 6 lists the intensity levels used, and as can be seen they range from a negligible level of one or less icebergs per 0.25 degree square area to an extreme case of more than 20 icebergs reported in the 0.25 degree square area over the coverage period.

Seasonal Iceberg Distribution

Winter

The winter iceberg distribution represented was compiled on the bases of seventeen northern survey flights which encompassed one flight in November, four in December and the remaining twelve in January. The southern limit of icebergs lies approximately midway along the Labrador coast, and terminates just south of the 56°N latitude. This approximates closely the southern limit of average sea ice cover during this season and indicate that the majority of icebergs are present in the pack ice, thereby ensuring negliable amounts of melting. The density distribution of icebergs is fairly low with only two relatively small localized regions of higher concentrations, off Cape Kakkiviak and Okak Island. The higher relative concentrations are essentially restricted to the inshore region, reflecting what is probably an association with the colder Baffin Island component of the Labrador current.

Table 6 Absolute Number of icebergs per 0.25 Degree latitude-longitude square used in the "Relative Concentration Scales" in the maps enclosed in the pocket of this report

	Number of Icebergs
Negligible	0 _ 1
Very Low	1 _ 2
Low	2 _ 5
Moderate	2 _ 10
Moderately High	10 _ 15
High	15 _ 20
Extreme	20

Spring

At the end of February, the sea ice cover has extended along the entire Labrador coast, and the majority of the icebergs encountered are trapped in the ice fields. The spring iceberg density distribution is based on eleven flights, eight of which occurred in February, two in March and one in April. The distribution reflects the prevailing influence of the Labrador current and particularly the frigid Baffin Island component. A central core of relatively high to extreme iceberg concentrations are seen paralleling the entire coast. Either side of this central core there is a rapid drop off in icebergs, both landwards and seawards. An interesting feature evident in this central core region is the convergence in the area near the Hamilton Inlet. The possibility of transient icebergs grounding in this region is substantiated by recent evidence which shows that iceberg scouring also increases in this area where the water depth decreases (van der Linden, et al., 1976). The prevailing winds during this period are controlled by a well-developed Icelandic low and North American continental high pressure systems, which produce a north westerly air flow conducive for spreading out the icebergs seaward.

Summer

The months of May through August reflect a time of warming surface waters and a gradual retreat of the sea ice. The summer distribution is based on seven flights, with two in May, three in June and two in August. The iceberg densities now appear both relatively lighter and more exclusively confined to the Baffin Island component of the Labrador current. The remnant of the high concentration seen in the spring distribution

area off Hamilton Inlet, although reduced, is still evident. The patchy distribution probably reflects the poor sample coverage available.

Fall

The fall iceberg density distribution is based on only five flights, which include four flights in September and one in October. The fall is represented by the warmest surface waters, and the lightest iceberg density concentration along the Labrador coast. The lack of adequate sample coverage resulted in a patchiness of the distribution.

With the dissolution of sea ice and the presence of warmer surface temperatures, iceberg deterioration which commenced in the summer is evident.

IV ICEBERG IMPACT PROBABILITIES

The most serious threat presented by icebergs in the Labrador Sea is that of a collision with vessels and offshore structures. Under calm conditions growlers can be detected by radar with reasonable reliability at distance of 3 to 5 km. However, during moderate and rough sea conditions, when sea clutter extends beyond 3 km on the radar scope, growlers large enough to cause serious damage to ships can pass undetected.

The probability of a collision between a stationary target and southerly drifting icebergs has been calculated for the Labrador coast using the impact probability equation of Blenkarr and Knapp (1966). Calculations to establish the annual and seasonal probability was based on an iceberg, 100 m across at the waterline, striking a drilling platform, 150 m in diameter. The unique probability of collision calculated for each one degree latitude is summarized in Table 7. This table accounts for the probability of only one iceberg hitting the drilling rig.

For comparison, the average probability of impact between an iceberg and a drilling rig on the Grand Banks south of St. John's, Newfoundland has been estimated to be in the order of 0.05 (Amoco Canada Petroleum Company Ltd., 1971). Duval et al. (1975) of Total Eastcan Exploration Ltd. have estimated for a summer operation the probability of an impact with a drilling ship is less than 0.10.

By using Anderson's (1971) monthly flux of icebergs across a line of latitude (Table 8) and calculations of the distribution in iceberg numbers along lines of latitude (Fig. 15), the flux numbers of icebergs across each degree of latitude were calculated per one degree of longitude from shore, both annually (Fig. 16) and seasonally (Fig. 17). The

Table 7 The probability, P(A), of a collision as a function of latitude between a 100 m wide iceberg and a 150 m wide drilling rig located in an area one degree latitude by one degree longitude

Latitude	$P(A) \times 10^3$
60	2.321
59	2.307
58	2.293
57	2.279
56	2.265
55	2.252
54	2.238
53	2.225
52	2.211

Table 8 Monthly average flux of icebergs across each degree of latitude (from Anderson, 1971)

FLUX ACROSS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
61°C	106	95	134	135	145	138	122	86	60	49	49	87	1206
60°N	103	95	128	131	144	142	124	87	51	40	40	74	1159
59°N	97	94	122	130	142	141	129	90	53	26	36	59	1119
58°N	87	92	115	129	139	140	135	95	62	21	26	43	1084
57°N	73	88	112	128	132	137	127	99	56	20	16	31	1019
56°N	49	77	112	112	133	134	122	106	68	28	10	19	966
55°N	31	59	99	105	126	130	120	118	75	35	11	10	909
54°N	17	39	82	98	116	118	91	81	49	32	15	6	744
53°N	12	30	73	93	111	107	64	54	33	23	11	2	613
52°N	9	23	62	89	106	102	42	34	22	14	9	0	512
51°N	4	14	40	76	86	67	37	11	2	5	5	0	347
50°N	3	8	35	66	75	32	22	5	1	2	3	0	263

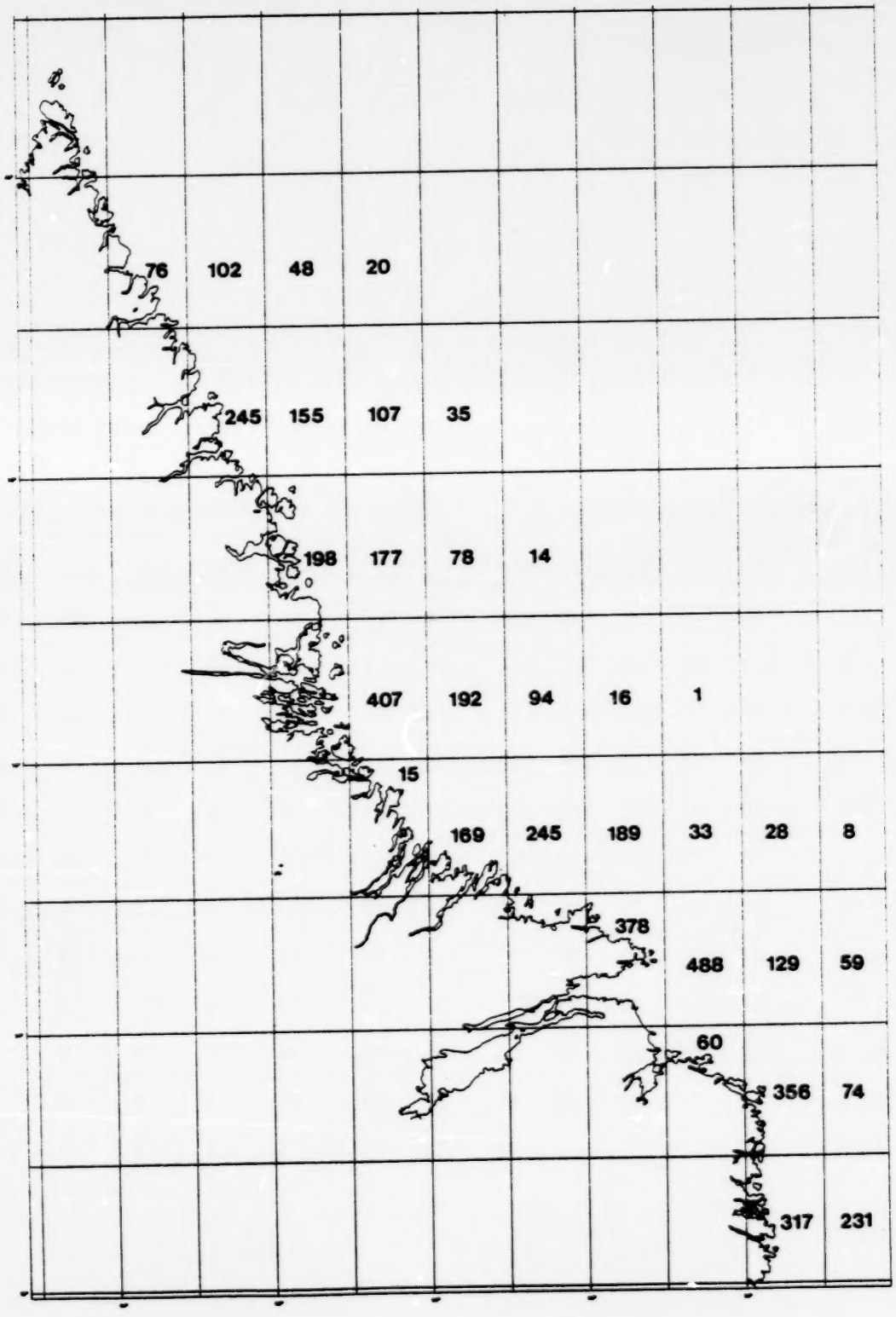

Figure 15 Number of icebergs sighted by the International Ice Patrol per degree square (1963-1967) (modified form Murray, 1969)

probability of one iceberg impact per degree latitude was then multiplied by the given number of icebergs crossing that latitude per degree longitude. This gives the probable number of impacts that a 150 m wide rig would suffer from a 100 m wide berg on both an annual and seasonal basis in the Labrador Sea. In Figures 16 and 17 the number of probable impacts were recorded along with the iceberg flux per degree square. Comparing these results to the CSS Hudson Cruise Report No. 78-002, where 6 out of 7 moorings in the area of the Labrador current appear to have been snagged by icebergs, reflect the conservative magnitude of these probabilities.

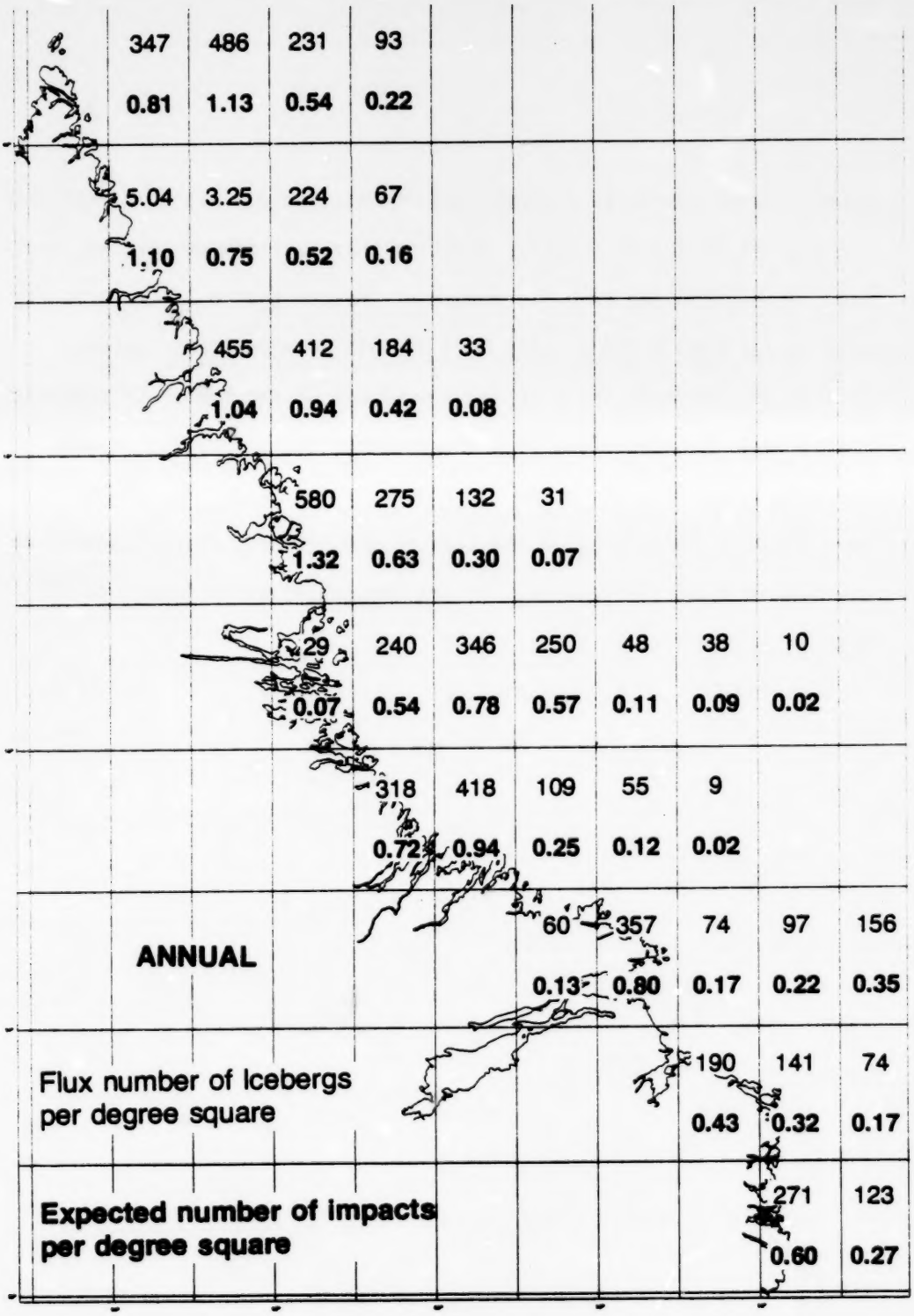

Figure 16 The flux number of icebergs per degree square and the number of iceberg impacts that 150 meter wide drilling platform would sustain over the entire year

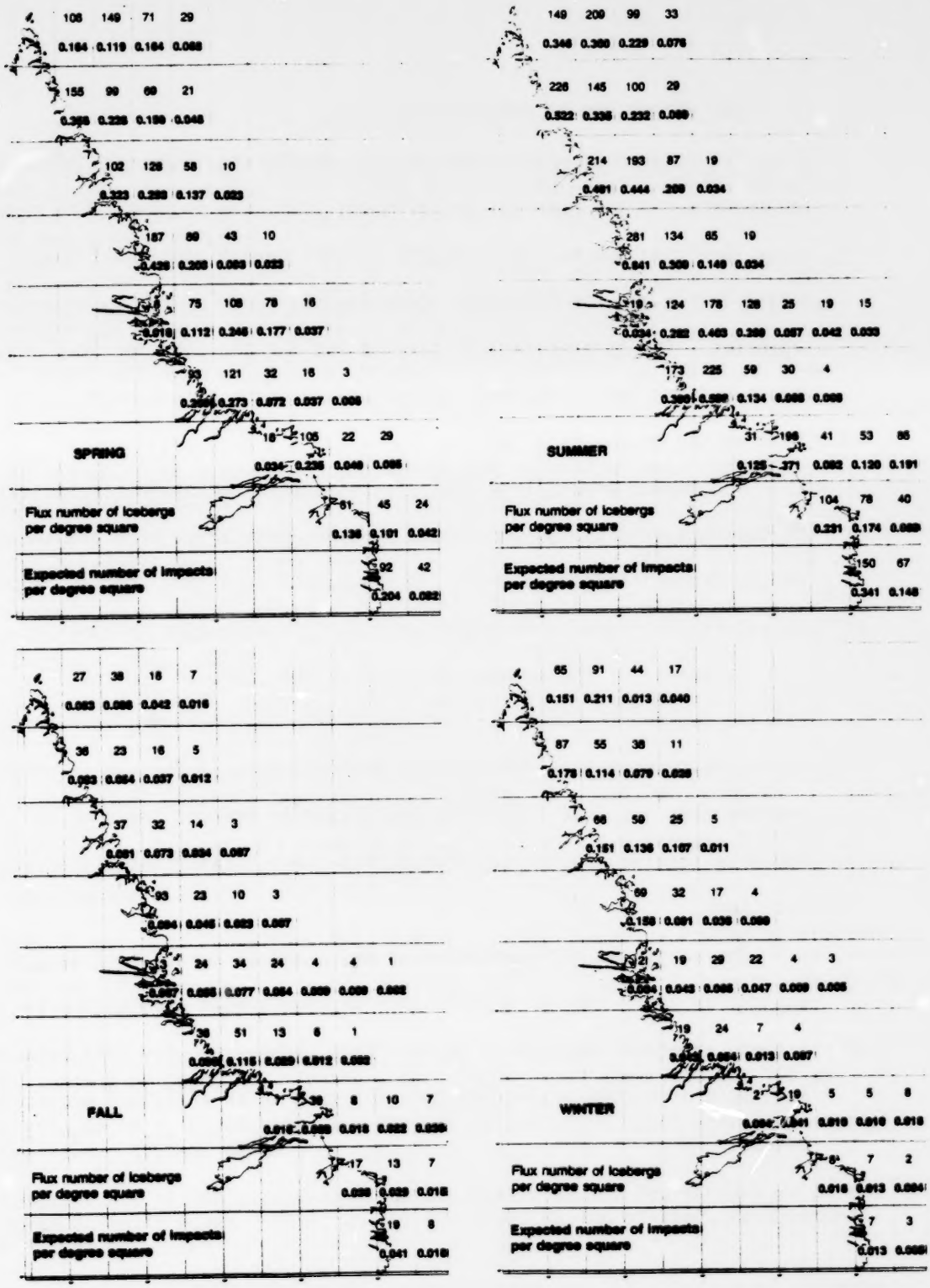

Figure 17 The flux number of icebergs per degree square and the number of iceberg impacts that 150 meter wide drilling platform would sustain over individual seasons

V CONCLUSIONS AND RECOMMENDATIONS

The attempt of this report was to compile and interpret information on icebergs in the Labrador Sea from all available sources. The magnetic data tape that now exists (Appendix 1) will permit additional data manipulation and handling, and hopefully may prove useful to other agencies. The interpretations carried out for the Labrador Sea, should now permit at least a general background on which both more refined studies can be contemplated.

The impact probability analysis reinforce some of the trends evident in the density distribution maps. However, both these maps and the impact probabilities are crude first attempts at a very complex problem which with increased development will require much more information.

Extension of the approaches used for the Labrador Sea could be carried out for the Davis Strait, and Baffin Bay, but much more information on iceberg location and size will be needed. The use of satellite imagery does not look like it is the answer at present (Dawe et al.,1978) and only regular (monthly) aerial survey flights can provide the required data bank.

Therefore the recommendation is made that an agency such as Ice Central in their regular surveillance program should also encompass iceberg size and location as an important parameter. The data bank now available in C-CORE could then be built upon in an efficient and useful manner.

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APPENDIX I - Digital Data Tape

To obtain a copy of the iceberg distribution data tape, a request should be made either to C-CORE or the Ocean Engineering Information Centre (OEIC) at Memorial University of Newfoundland. The information is in the standard IBM Fortran format.

An individual sighting is recorded as a ten digit number followed by two letters. The first two digits correspond to the number of icebergs reported at that location, and are predominantly 01 corresponding to a single iceberg. The next four digits correspond to latitude, i.e. 50°16', and the last four digits correspond to longitude 58°30'. The last two spaces are letters with the following coding:

RT - radar target

GR - growler

XX - more than one iceberg with a variety of sizes and shapes

S_ - small

M_ - medium

L_ - large

_D - domed

_P - pinnacle

_K - dry dock

_B - blocky

Each flight is designated by a ten digit number. The first two numbers correspond to unique flight number as shown in Table 6, the next two numbers stand for the date, the next two for the month, and the final four for the year. The flight information proceeds the iceberg recorded on that flight.